OPERATIONAL REQUIREMENTS DOCUMENT

LOCAL AREA AUGMENTATION SYSTEM

(LAAS)

APPLICATION OF SATELLITE NAVIGATION CAPABILITY

FOR CIVIL AVIATION

FEDERAL AVIATION ADMINISTRATION

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1. General Description of Operational Capability

The Federal Aviation Administration (FAA) has the statutory authority to establish, operate, and maintain navigation capability for all phases of flight. This mission must be performed to ensure that navigation service is available where needed and that it is provided in a cost-effective manner. In order for the FAA to better accomplish its mission, a satellite navigation capability with the required integrity, continuity, accuracy, and availability must be provided. This capability should support (1) all-weather operations for all phases of flight, (2) air traffic capacity enhancements, and (3) future technology enhancements. It should be a seamless navigation system suitable for use in all aircraft types and airspace.

The FAA, the International Civil Aviation Organization (ICAO), and other members of the civilian aviation community have recognized that the primary means of radio navigation for the 21st century will be a Global Navigation Satellite System (GNSS). In September 1991, the United States formally offered the Global Positioning System (GPS) as an element of the GNSS on a worldwide, continuous basis for the foreseeable future with no direct user charges.

GPS provides a practical starting point for the eventual development of the GNSS. However, GPS, as designed, developed and deployed by the Department of Defense (DOD) will not totally satisfy all civil aviation requirements for navigation and landing. For use in civil aviation, augmentations will be required to improve GPS accuracy for precision approaches, provide integrity and continuity for all phases of flight, and provide availability necessary to meet primary means of radio navigation requirements. This augmentation is iterative in nature. The first step in this augmentation is the Wide Area Augmentation System (WAAS) which is designed to provide navigation and landing capability down to or near the lowest Category I decision height of 200'. The second step is the Local Area Augmentation System (LAAS). The LAAS is being designed to assume the GNSS mission where the WAAS leaves off. In practical terms, this means that at locations where the WAAS is unable to meet existing navigation and landing requirements (such as availability), the LAAS will be used to fulfill those requirements. In addition, the LAAS will meet the more stringent CAT II/III requirements that exist. Beyond CAT III, the LAAS will provide the user with an all weather Surface Navigation capability.

The LAAS will provide the above requirements at a significant improvement in service flexibility, safety, and user operating costs. High quality navigation services will be provided without investing in numerous expensive ground facilities, eventually resulting in savings to the U.S. Government. Aircraft operators will gain from the reduced expense of purchasing different types of radio navigation equipment (the plan is to use the same aircraft equipment to accomplish both the WAAS and LAAS missions), reduce avionics maintenance costs, and realize savings in aircrew training. Air traffic service providers will be able to offer services that are not currently economical and practical, such as Category I service to locations where the environment precludes the availability required for use of the WAAS. Adoption of the LAAS will permit the phase-out of selected existing National Airspace System (NAS) ground based radio navigation equipment.

2. Operational Concept.

The GPS/LAAS will initially be used in the NAS as a supplemental system and eventually mature into a major component of the primary means of radio navigation. The LAAS will be used in conjunction with the Wide Area Augmentation System (WAAS) to ensure that all user requirements for precision approach are being met. Additionally, the LAAS will provide surface navigation to all users that require such service. The LAAS may be implemented in a phased approach. The first phase will provide the capability to supplement the WAAS where necessary to ensure Category I service is provided to all NAS users that desire the capability. Phase two will bring LAAS into Category II/III service. Finally, Phase three will provide Surface Navigation capability to all desired users.

The GPS/LAAS will steadily transition and integrate with the WAAS and other NAS capabilities to create a GPS based navigation and landing system. Air Traffic initiatives will be designed to allow LAAS integration and expanded use in the now existing ILS/MLS based landing environment. Precision (Category II/III) approaches and Surface Navigation capabilities will eventually be implemented. The GPS/LAAS will support implementation of the GPS/WAAS based airspace and air traffic structure. The GPS/LAAS capability may be fully exploited in the areas of surface navigation, obstacle and terrain clearance, instrument approaches, time separation, and Automatic Dependent Surveillance (ADS) implementation.

Implementation of the LAAS will primarily affect the following groups of people associated with the NAS:

Air Traffic Controllers: Controllers will be dealing with a seamless navigation system for all phases of flight using GPS, WAAS and LAAS. Controllers will also be able to provide improved surface navigation capability to their customers (air carriers, business, and general aviation).

Pilots: The LAAS will provide pilots further reduced cockpit workload by integrating the GPS/WAAS/LAAS into primary means of radio navigation. As with the WAAS, the LAAS will reduce pilot training requirements by reducing the number of required navigation systems onboard

Airway Facilities Personnel: The number of navigation and surveillance systems that must be maintained will be reduced with the implementation of the LAAS. The life cycle for the LAAS will be twenty years with replacement of hardware every five to seven years. This will provide system maintainers with a state of the art system that will be more easily maintained. Software will be upgraded as required over the life cycle of the LAAS.

The GPS/LAAS will have an impact on existing operational procedures, rules and human interfaces. As the LAAS is implemented, the associated FAA Orders, manuals and directives, Federal Aviation Regulations, Terminal Instrument/Surface Navigation Procedures, etc. will require revision to take advantage of the GPS/LAAS capabilities. The LAAS human interface will be simplified through standardization of the LAAS equipment and subsystems. Adequate and ample training is a key to the LAAS implementation and will be required for pilots, air traffic, and airway facility personnel.

3. Capabilities Required.

The LAAS will be used for Category (CAT) I, II, and III approaches, including Category IIIb which requires navigational system guidance through rollout. Other likely or potential applications of the LAAS include the following: departure, high speed turnoffs, missed approach, vertical takeoff and landing operations, flare initiation over uneven terrain, and general terminal area navigation.

a. System Performance.

(1) Accuracy is defined as the degree of conformance between an estimated or measured value at a given time and its true value. LAAS accuracy requirements are stated in terms of Path Following Error (PFE), Path Following Noise (PFN), and Control Motion Noise (CMN) as defined in ICAO Annex 10. Category I and II requirements on the 95th percentile navigation system error due to the combination of Signal-in-Space (SIS) and avionics equipment are as listed below. PFE includes all sources of navigation system error due not only to vertical sensor error, but also to longitudinal sensor error. Category II aircraft may be assumed to have a single radar altimeter augmenting LAAS performance.

	Threshold (m)	Objective (m)
PFE (horizontal)	7.9	5.3
PFE (vertical)	4.3	2.8
PFN (horizontal)	3.8	3.8
PFN (vertical)	0.9	0.9
CMN (horizontal)	4.4	4.4
CMN (vertical)	1.5	1.5

Table 1. LAAS Category I Accuracy Requirements

	Threshold (m)	Objective (m)
PFE (horizontal)	5.5	4.4
PFE (vertical)	1.8	1.3
PFN (horizontal)	3.4	3.4
PFN (vertical)	0.5	0.4
CMN (horizontal)	3.6	3.6
CMN (vertical)	0.7	0.7

Table 2. LAAS Category II Accuracy Requirements (95^{th} Percentile)

Category III accuracy requirements are the 95^{th} percentile touchdown zone accuracy and dispersion requirements described in FAA Advisory Circular 20-57A (rather than navigation system error). Dual radar altimeters may be assumed to be augmenting LAAS performance on Category III aircraft. Figures listed below indicate limits of the dispersion zone, but touchdowns need not be symmetrically distributed within that zone. Longitudinal limits indicate total touchdown zone dimensions whereas lateral limits are stated as distances from runway centerline.

Touchdown Dispersion	Threshold (m)	Objective (m)
95^{th} Percentile Lateral	8.2	6.1
95^{th} Percentile Longitudinal	460	460
1×10^{-7} Lateral	21	21
1×10^{-7} Longitudinal	670	670

Table 3. LAAS Category III Accuracy Requirements

Note that these figures are consistent with the requirements of AC 20-57A. The outer touchdown zone begins 200 feet beyond the threshold and extends to approximately 2400 feet yielding a total touchdown zone length of 2200 feet (670 meters).

(2). Integrity is defined as the ability of a system to provide timely warnings to users when the system should not be used for navigation. The probability of Hazardously Misleading Information (HMI) and navigation system time-to-alarm are as shown in tables 4 and 5.

Note: probabilities are calculated based on standardized time periods for each category of approach. These time periods are: 150 seconds for CAT I, 165 seconds for CAT II, 200 seconds for CAT IIIa, and 230 seconds for CAT IIIb.

	Probability of HMI, per approach—Threshold **(Signal In Space)**	Probability of HMI, per approach—Objective **(Signal In Space)**
CAT I	4×10^{-8}	4×10^{-8}
CAT II	4×10^{-8}	4×10^{-8}
CAT III	4×10^{-8}	4×10^{-8}

Table 4. LAAS Probability of HMI Requirements

	Time to Alarm Threshold (seconds)	Time to Alarm Objective (seconds)
CAT I	6	6
CAT II	2	1
CAT III	2	1

Table 5. LAAS Integrity Time-to-Alarm Requirements

(3) Continuity of Function (COF) is defined as the probability that the Signal-in-Space supports navigation accuracy and integrity requirements for the duration of a period of intended operation, presuming that the system was available at the beginning of that period. For category I and II installations, the period is the length of the approach. Category III approaches, however, are analyzed in two separate periods. The first covers the entire approach from beginning to end and is identical to that associated with calculation of Integrity probabilities. The second only covers a limited period at the end (and most critical) portion of the approach. The LAAS Signal-in-Space Continuity of Function requirements are defined in table 6.

	Probability of Loss of Continuity—Threshold (Signal in Space)	**Probability of Loss of Continuity—Objective (Signal in Space)**
CAT I	5.5×10^{-5} per approach	5.5×10^{-5} per approach
CAT II	5.5×10^{-5} per approach	4×10^{-5} per approach
CAT III a	4×10^{-5} per entire approach	4×10^{-5} per entire approach, 10^{-7} for final 50 seconds of approach
CAT IIIb	3×10^{-5} per entire approach (including rollout), and 10^{-7} for final 30 seconds of approach and rollout.	3×10^{-5} per entire approach (including rollout), and 10^{-7} for final 80 seconds of approach and rollout.

Table 6. LAAS Continuity Requirements

(4) Availability is defined as the probability that the navigation and fault detection functions are operational and that the GPS/LAAS Signal-in-Space accuracy, integrity, and Continuity of Function requirements are met. Availability requirements are between 0.999 and 0.99999 per airport averaged over a year. It is desirable to be able to add availability to a particular location through installation of additional equipment (or other reasonable means). In this way, the expense of higher availability can be avoided at locations where it is not required.

(5) Alternate Airport: An outage of approach capability at the primary airport (WAAS or LAAS) should be as independent as possible of an outage of approach capability at the alternate (LAAS) airport.

(6) Interference Rejection: LAAS equipment should function within the specifications in the normal High-Intensity Radiated Field (HIRF) environment as specified by AE4R Subcommittee of SAE.
(7) Security Requirements: There is no civil requirement for encryption. Further input is required from DOD on whether certain military applications require encryption.
(8) There is no requirement that the Signal-in-Space produced by all LAAS ground systems meet CAT IIIb requirements (For example, there may be an advantage in building less expensive systems for locations where only a CAT II capability is needed.) However, all LAAS avionics (whether CAT I, II, or IIIa/b) must be able to conduct approaches using the LAAS Signal-in-Space broadcast by all types of LAAS ground systems.
(9) The LAAS will provide for seamless transition between the WAAS or the GPS Supplemental Positioning Service (SPS) and the LAAS approach environment.
(10) The LAAS will be capable of being operated and maintained in a safe and cost effective manner, and will be maintainable by the FAA.
(l1) The GPS/LAAS will provide a usable interface with the Notice to Airman (NOTAM) information system for safe flight planning purposes. The existing NOTAM system must be expanded to incorporate the GPS/LAAS information.

b. Supportability.

(1) Maintenance support for the Local Area Augmentation System (LAAS) will be guided by FAA Order 6000.30B, Policy for Maintenance of the NAS through the year 2000, which details a two level maintenance philosophy: field and depot. The LAAS will use modular design equipment which will enable field level personnel to correct equipment failures on-site by replacing faulty Line Replaceable Units (LRUs). The Mean-Time-To-Repair will be less than 30 minutes. This repair time will include diagnostic time, removal of the failed LRU, including any adjustments or data loading necessary to initialize the LRU, and all adjustments required to return the LAAS to an operational condition.
(2) LAAS shall be designed to meet or exceed a Mean-Time-Between-Failure (MBTF) requirement of 2190 hours.
(3) Preventive maintenance for the LAAS will not exceed 4 site visits per year or 1 per quarter.

4. Critical Operational Issues.

a. System Quantities.

(1) There will be multiple Local Area Augmentation Systems that will provide the following range of capabilities: Terminal Area Navigation, Category I Precision Approach, Category II/III Precision Approaches, and Surface Navigation.
(2) At full implementation the number of airports requiring LAAS capability will at least equal or exceed the present number equipped with ILS CAT II/CAT III or multiple ILS installations of any type. Currently, there are approximately 600 ILS equipped airports in the U.S. Of those, about 80 are equipped with Category II or III systems (source: MITRE WN 94W0000057, “National Airspace System Precision Approach and Landing System (NASPALS): Candidate Architecture Descriptions”).
(3) No spare systems will be required. However, spare parts to maintain the LAAS will be required. Initial spare LRUs and other components required to maintain the LAAS will be initially determined by the interim contract maintenance and logistics support (ICMLS) contractor.

b. Schedule Constraints.

(1) The LAAS should be developed, procured, and implemented on a schedule which complements the WAAS implementation. The LAAS will provide Category I Precision Approach capability at selected locations where the WAAS cannot. Based upon analysis, initial operation capability (IOC) should occur in the summer of the year 2000, but not later than the fall of the year 2002.
(2) Initial operational capability will occur after the completion of the following: Contractor Acceptance Inspection (CAI), Operational Test and Evaluation (OT&E), the Deployment Readiness Review process (DRR), and operational acceptance of the first LAAS Category I/II/III or Surface Navigation system installation. Full Operational Capability (FOC) will occur when LAASs are deployed in all the existing Category II and III locations.

c. Standardization and Commonality.

(1) The LAAS must be compatible with existing AF and airport facilities and must be capable of interfacing with the Remote Maintenance Monitoring System (RMMS). Hardware for the LAAS will be standardized throughout the system.
(2) The LAAS must provide Air Traffic Control the following information :

(a) the status and configuration of all LAAS components and equipment at each LAAS location.
(b) representation of the GPS/LAAS coverage.
(c) representation of the service being provided to the coverage area (precision approach (Cat I,II,III) and surface navigation).
(d) status of GPS satellites.

d. User Requirement.

The LAAS must be upwardly compatible so that a CAT III LAAS ground system supports a CAT I LAAS airborne installation. Similarly, the LAAS receiver will be compatible with the WAAS or the GPS SPS to facilitate navigation into and out of the region. In addition, minimal modifications should be required for a WAAS receiver to use the LAAS for CAT I, CAT II, or CAT III approaches.

5. Support Concept.

a. Maintenance Concept. As stated previously, maintenance support for the LAAS will be guided by FAA Order 6000.30B, Policy for Maintenance of the NAS through the year 2000, which details a two level maintenance philosophy, field and depot. Field level maintenance will consist of all maintenance activities performed on equipment installed in the equipment's operating environment and includes both preventive and corrective maintenance actions. Depot-level maintenance consists of reordering or repairing failed LRUs which are shipped from the site. The LAAS will utilize this field and depot maintenance concept throughout its operational life cycle.

Upon transitioning to full FAA support, a structured maintenance and logistics support approach will be executed. Due to the criticality of the system, field level periodic and corrective maintenance for both hardware and software will be accomplished by FAA personnel. Repair of LRUs will be accomplished by the FAALC. Second-level engineering, hardware and software support will be provided by the National Automation and Hardware Engineering Field Support Divisions (AOS-200/300).

b. NAS Integrated Logistics Support Concept. Mission operational availability, reliability, and maintainability of the LAAS will be ensured through the following system characteristics:

(1) Remote Maintenance Monitoring: The LAAS equipment shall be designed to provide remote status and diagnostics information to the monitoring and control facility.
(2) Availability: The MTBF of each LAAS subsystem should meet or exceed 2190 hours, have an availability of .99975 or greater, and have no interruptions exceeding 4 hours or occurring more often than once a quarter. The mean-time-to-repair a LAAS subsystem should be less than 30 minutes. This repair time will include diagnostic time, removal of the failed LAAS subsystem, replacement and installation of the new LAAS subsystem including any adjustments or data loading necessary to initialize the LAAS subsystem, and all adjustments required to return the LAAS subsystem to normal operation. Service Restoration of the LAAS will conform to FAA Order 6030.31E, Restoration of Operational Facilities.
(3) Support Equipment: Requirements for support equipment, software and automatic test equipment will be identified as early as possible and included in the acquisition process. Use of FAA standard test equipment in lieu of unique test equipment is preferred but may not be feasible. In any event, no new special test equipment should be necessary after the developmental phase. However, a determination should be made regarding the need for new maintenance and calibration standards and procedures to support any required tools and test equipment.
(4) Initial Spares: FAA Order 6000.38, Policy to Determine NAS Equipment Initial Sparing Requirements for Airway Facilities Work Center Locations and Field Locations, shall be used by FAA/ALM to identify and quantify the items and quantities of initial spare parts to be used as field spares and to identify those locations that require site spares.
(5) Configuration Management: The LAAS should be designed to ensure that the minimum essential number of hardware configurations, manuals, drawings, and spares are to be supported.
(6) Packaging and Handling: LAAS packaging and handling requirements of support equipment and spares are considered routine and will be guided by the applicable standards listed in the Integrated Logistics Support Plan (ILSP).

c. Computer Resources.

(1) For most critical LAAS applications, certification requirements of DO-178B will apply.
(2) Under worst case loading conditions, no more than 50% of the total addressable, populated memory locations will be used during the execution of any program to hold instructions or data.
(3) All LAAS computer memory shall be capable of having its total amount of each type of memory increased by 100%.
(4) Each processor (including input/output subsystems) in the LAAS that executes software in support of system performance requirements shall use no more than 70% of the processor’s throughput capability under worst case conditions.

6. Critical System Characteristics.

a. Accuracy. As a minimum, the LAAS must satisfy the accuracy threshold requirements specified in section 3.a.(2) of this document.
b. Integrity. As a minimum, the LAAS must satisfy the integrity threshold requirements specified in section 3.a.(3) of this document.
c. Continuity of Function. As a minimum, the LAAS must satisfy the COF threshold requirements specified in section 3.a.(4) of this document.
d. Availability. As a minimum, the LAAS must exhibit an availability of .999 per airport averaged over a one year period.

7. Infrastructure Support.

The LAAS is dependent upon the GPS standard positioning service (SPS) satellite signal. The LAAS cannot function without the GPS signal.

The user's receiver must meet the design criteria of the appropriate Technical Standard Order (TSO).

The LAAS must be capable of interfacing with the Remote Maintenance Monitoring System.

The LAAS must be capable of interfacing with the NAS to provide NAS required data, including status and performance data. NAS to LAAS interface capability must exist so that all of the manual entry data and control can be entered at the Operation Control Center by Airway Facilities NAS systems personnel.

New concepts, new procedures, and new standards will need to be developed in order to reap all the potential benefits provided by the highly precise and reliable GPS/LAAS signals. Areas such as airworthiness, operational approval, obstacle clearance, and aircraft separation and traffic management requirements will require review in light of the capabilities provided by the GPS/LAAS.